Unit 8

Integrated Nutrient Management

Introduction

Integrated Nutrient Management (INM) refers to the combined use of organic, inorganic and bio-fertilisers, and inclusion of blue green algae or *azolla*, etc., to meet the nutritional requirements of a crop. It also includes different sources of nutrient supplementation to create a conducive environment for soil conditioning in order to build soil fertility. The carbon and nitrogen ratio (C:N ratio) of the soil is maintained under INM, which in turn provides highly favourable conditions for crop performance.

Session 1: Soil Sampling and Analysis

Paddy plant takes relatively small amounts of nutrients in the early stages of growth but the quantity intake increases as the plant grows. However, as the plant grows, the daily nutrient intake increases. So, there is a need to provide adequate nutrients to a plant during its developing stages. It is, therefore, necessary to check the nutrient status of soil every year or at an interval of two to three years. This will help in:

- avoiding indiscriminate use of fertilisers (which can be expensive, as well as, wasteful) and ensuring environmental safety.
- maintaining and restoring soil fertility to ensure crop productivity, profitability and sustainability.

To know the status of various nutrients, soil fertility level, pH, etc., by soil testing, it is important to know the fertility status and physical properties of the soil. This will enable maximum production and rational soil management. A soil test programme consists of three basic steps.

- Soil sampling
- Soil sample analysis
- Soil test interpretation

Purposes of soil testing

- It helps evaluate and improve soil productivity.
- It determines the nature of the soil, i.e., alkalinity, salinity or acidic.
- It helps make appropriate use of fertilisers.
- It reveals the condition of soil so that it can be improved with the application of necessary nutrients and implementing other management practices.

Soil sampling

Soil tests and their interpretations are based on the collection of soil samples, and their analysis. Therefore, the samples must be collected in a zigzag pattern from various points, which represent the whole field. To obtain right information about the nutrient status of the soil, it is important to follow the correct procedure of soil sampling.

Fig 8.1: Hand auger to draw soil sample

Before sampling information about the cropping pattern, various management practices being followed in the field, variation along with direction of the slope, soil colour and texture need to be noted. Then, the field from where the samples have to be collected must be divided into sections according to variations in slope and texture, and separate samples need to be collected from each section by using sampling tools like hand auger (Fig. 8.1). Soil samples can also be collected with the help of a spade or *khurpi* by giving a slanting cut to the soil at up to 15 cm depth, creating a 15-cm wide V–notch (triangular/V–shape cut, Fig. 8.2).

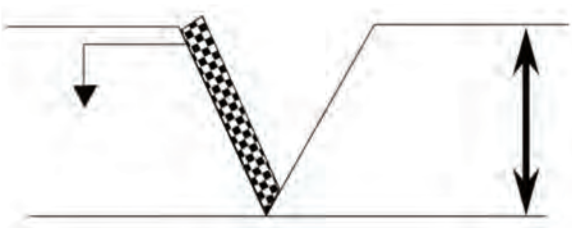

Fig. 8.2: Soil sampling by V-notch method

The samples must be collected from plough depth, i.e., 15 cm for normal agronomic crops and from deeper zones, i.e., 15–30 cm for deep-rooted crops at different spots, and then, all are mixed thoroughly. This composite soil sample is then spread on a clean sheet. It is divided into four equal parts. Two opposite quarters are rejected and the samples from the other two are mixed. To obtain the desired size of the sample (500 g), the procedure is repeated. Before sending the sample to a laboratory, it must be dried and put into plastic bags. The sample bags must be labelled and sent to the nearest soil testing laboratory along with an information sheet, containing the following information.

- Name and address of the farmer
- Identification or number of the field
- Date of sampling
- Local name of the soil, if any
- Colour of the soil (dry or moist)
- Type of land (unirrigated, irrigated or waterlogged)
- Source of irrigation (canal, well or tank)
- Depth of sampling
- Topography (level, sloppy or undulated)
- Crop rotation followed
- Previous crop
- Next crop to be taken
- Details of manures or soil amendments applied earlier to the soil
- Other remarks

The help of a village level or extension worker can be taken to collect the soil samples and in filling the information sheet.

Soil analysis

This is done primarily to check NPK (Nitrogen, Phosphorous and Potassium) content, organic carbon content, electrical conductivity and pH level. It is mainly done in cases, where the crop has shown deficiency symptoms of micronutrients. The collected samples

are analysed by using standardised method in the laboratory for the following parameters.

- pH: It indicates whether the soil is acidic, alkaline or neutral in nature.
- Total soluble salts as determined by electrical conductivity (EC) indicates the degree of salinity, alkalinity, etc., of the soil.
- It also helps in ascertaining the soil's lime and gypsum requirement.
- It also helps in finding out the level of organic carbon, which is a measure of nitrogen available in the soil.
- It helps in ascertaining phosphorus and potassium content in the soil.

Notes

Soil test interpretations

On the basis of the soil analysis report, one can identify various deficient nutrients with the help of rating charts. The data obtained from soil analysis would be meaningless unless it is correlated with the crop yield, so the report provides this information also. Based on the soil analysis, the data can be interpreted with the help of ratings as given in the following tables.

Table 8.1: Rating of soil on the basis of pH

S. No.	Type of soil	Soil reaction (pH)
1.	Acidic	Less than 6
2.	Normal to saline	6–8.5
3.	Tending to become alkaline	8.6–9
4.	Alkaline	More than 9

Table 8.2: Rating of soil on the basis of Electrical Conductivity (EC)

S. No.	Category	EC (dS/m)
1.	Normal	Less than 1
2.	Critical for germination	1–2
3.	Critical salt levels for growth of sensitive crops	2–4
4.	Injurious to most crops	More than 4

Notes

On the basis of the soil test interpretations, fertiliser recommendations for each crop may be made. The soil fertility status as per its classification into three strata (low, medium or high) is also provided. An example of this 'rating chart' is shown in Table 8.3

Table 8.3: Rating on the basis of nutrient availability

S. No.	Nutrient	Low	Medium	High
1.	Organic carbon	Less than 0.5%	0.5–0.75%	More than 0.75%
2.	Available nitrogen (N)	Less than 280 kg/ha	280–560 kg/ha	More than 560 kg/ha
3.	Available phosphorus (P)	Less than 10 kg/ha	10–25 kg/ha	More than 25 kg/ha
4.	Available potassium (K)	Less than 110 kg/ha	110–280 kg/ha	More than 280 kg/ha

Practical Exercise

Activity

Demonstrate the procedure of soil sampling.

Material required: hand auger, test tube, spade, cultivated field, paper bag, polythene bag and tag

Procedure

- Divide the field into different homogenous units, according to fertility levels.
- Remove weeds, roots, etc., at the sampling spot.
- Take samples from a depth of up to 15 cm with the help of auger, spade or *khurpi*.
- From each sampling unit, collect at least 10 samples.
- Remove all foreign material and mix the samples evenly.
- Divide the collected samples into four equal parts.
- The two opposite quarters are removed and remaining samples from two other parts are mixed. The process is repeated until the desired sample size is obtained.
- Dry the moist sample.
- Collect the prepared sample in a sampling bag.
- Label the bag with following information, i.e., name and address of the farmer, date of collection, previous and present crop record, crop to be grown in the next season, etc.

Check Your Progress

A. Fill in the Blanks

1. For deep-rooted crops, soil samples must be collected from __________ cm deep zone.
2. The desired size of the sample for soil testing is ____________.
3. Collect the soil sample in a ____________ pattern to represent the whole field.
4. The pH of alkaline soil is ___________.

B. Multiple Choice Questions

1. The available nitrogen status in soil is considered low at _________ level.
   (a) less than 240 kg/ha (b) 240–380 kg/h
   (c) 380–480 kg/ha (d) 480–580 kg/ha
2. The available potassium status in soil is considered high at ___________ kg/ha.
   (a) Less than 100 kg/ha (b) Less than 110 kg/ha
   (c) 110–280 kg/ha (d) More than 280 kg/ha
3. Soil is injurious to most crops if EC (milli mohs/cm) is ____________.
   (a) > 2 (b) > 3 (c) > 4 (d) > 5

C. Match the Columns

A	B
1. INM	(a) Electrical Conductivity
2. V–notch	(b) Soil sampling
3. dS/m	(c) Use of organic, inorganic and bio-fertilisers
4. Auger	(d) Triangular vertical cut

D. Subjective Questions

1. Define soil sampling.
2. Write the procedure of soil conducting sampling.

Session 2: Nutrient Requirement and its Sources

Essential nutrients required by plants

Plants require food for growth and development. A large number of nutrients are absorbed by plants from soil, air and water. Seventeen elements are essential for the

Notes

growth and development of plants. The criteria to judge the essentiality of an element are as follows.

- Deficiency of a particular nutrient makes it difficult for the plant to complete its vegetative or reproductive life cycle.
- Deficiency of a specific nutrient can be corrected by providing that particular element to the plant.
- The nutrients are directly involved in the plant's metabolic activities.

Macro nutrients

Primary nutrients

Out of the 17 essential nutrients, nitrogen (N), phosphorous (P) and potassium (K) are called the primary nutrients because plants need them in large quantities.

Secondary nutrients

Magnesium (Mg), calcium (Ca) and sulphur (S) are the secondary nutrients as they are required in moderate quantities.

Micronutrients

Manganese (Mn), zinc (Zn), boron (B), iron (Fe), copper (Cu), chlorine (Cl), molybdenum (Mo) and nickel (Ni) are micronutrients, and are required in small quantities. Carbon (C), hydrogen (H) and oxygen (O) are obtained from air and water. But all these nutrients, irrespective of the class to which they belong, are essential for plant life. Deficiency or excess of any nutrient limits plant growth.

Sources of nutrients

Plants meet their nutrient requirements from different sources like fertilisers, manures, plant residues and bio-fertilisers. Non-proportional and inappropriate use of fertilisers can damage crops, waste money, possibly lead to dependence of the plants on chemical inputs and deterioration of soil health. Natural biomass can also serve as a source of nutrient for crop plants and can be used after appropriate treatment or conversion, and in some cases even in raw form.

Organic sources

The decomposed remains of plants and animals are used as organic manure for growing plants. Legume plants are used for either green manuring or making enriched composts for recycling of nutrients. Nitrogen fixing bacteria, blue-green algae and solubilising bacteria can serve as organic sources of nutrient supplementation. Organic sources of nutrients are organic manures, green manuring, bio-fertilisers, etc.

Organic manure

Organic manures supply nutrients in a balanced proportion. Usually, large quantities of organic manures are required to meet the crop nutrient requirement. Organic manures include FYM, vermicompost, poultry manure, biogas slurry, etc. These manures are applied to the soil by spreading or broadcasting before sowing or transplanting paddy.

Fig. 8.3: Organic manure

Green manuring

Growing and incorporation of tender biomass of legume crops in soil is known as 'green manuring'. These crop plants fix atmospheric nitrogen, and after decomposition and incorporation, release this nitrogen into the soil, which helps improve its physical and biological properties.

Table 8.4: Green manure crops

Green manure crops	Seed rate (kg/ha)	Green biomass (t/ha)
Sithagathi (*Sesbania speciosa*)	30–40	15–18
Dhaincha (*Sesbania aculeata*)	50	25
Manila agathi (*Sesbania rostrata*)	40	20
Sunnhemp (*Crotalaria juncea*)	25–35	13–15
Wild indigo (*Tephrosiapurpurea*)	15–20	6–7

Fig. 8.4: Green manuring crop Sunnhemp (Crotalaria juncea)

Fig. 8.5: Dhaincha (Sesbania aculeate)

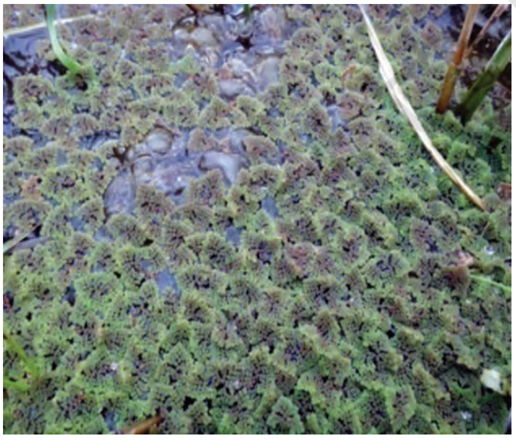

Fig. 8.6: Bio-fertiliser (Azolla)

Green manuring in paddy crop

Sow sunnhemp or *dhaincha* (green manure crop) seeds at the rate of 20kg/ha during summer. The biomass is incorporated into the soil after 40 days of sowing and allowed to decompose *in situ* (on site). This decomposes easily in 10–15 days, after which paddy can be grown in the field. If it is not possible to grow green manuring crop in the field, incorporate the already decomposed green leaves of different plants (neem, pongamia, ipomea, etc.) at 2–3 t/ha, which serves the same purpose as green manure crop. It adds nitrogen and humus to maintain the soil health.

Bio-fertiliser

Bio-fertilisers are eco-friendly and are ready to use live formulations, containing strains of beneficial microorganisms. These microorganisms on application to seed, root or soil help enhance the availability of essential nutrients to the crop and also help build beneficial micro-flora in the soil, thereby, improving the soil health. They are an integral part of INM, which helps in meeting the nutrient requirement of the plant at low cost. Bio-fertilisers that can be used for paddy crop include *azolla*, blue-green algae, *azotobacter, azospirillum, phosphobacteria,* phosphate solubilisers and *mycorrhizae*.

Bio-fertiliser application

Bio-fertilisers are available as carrier-based inoculants. The common filler material used as a carrier include peat or lignite. These bacterial inoculants are, usually, applied for seed treatment. Sometimes, these bio-fertilisers are applied as seedling root dip or directly for field application.

Table 8.5 Quantity of bio-fertilisers required per hectare

Method of application	Number of packets (200g/ha)
Seed treatment	5
Nursery application	10
Seedling dip	5
Main field (soil application)	10

Inorganic sources

Inorganic fertilisers are chemical compounds (either synthesised or natural) that are added to the soil to improve its fertility on an immediate basis. These fertilisers are economical, quick responding and provide the required nutrient element that can increase the crop yield, thereby, resulting in significant profits. As per their chemical composition, these fertilisers may contain one or more nutrient element. A fertiliser, which contains only one of the primary nutrient elements, is called 'single element' or 'sole fertiliser', for example N, P and K.

Some fertilisers contain a combination of primary nutrient elements (N and P, N and K, or P and K) and are known as 'complex' or 'mixed fertilisers'. Those containing N, P and K are called 'complete fertilisers'.

The nutrient content of fertilisers is expressed in per cent. Thus, the total weight of fertilisers does not reflect the quantity of nutrients it contains. For example, a 100-kg bag of Diammonium phosphate (18% N and 46% P) contains 18 kg of N and 46 kg of P, and remaining 36 kg of inert material; 100-kg bag of urea (46% N) contains 46 kg N and 54 kg inert material.

Sources of micronutrient fertilisers

Out of 17 essential nutrients, iron, molybdenum, manganese, zinc, chlorine and sulphates of copper are required for plant growth in small quantities and are known as micronutrients. Micronutrients like sulphates of copper, iron, manganese and zinc are soluble in water, and can be easily applied through foliar application or along with irrigation water.

NOTES

NOTES

Table 8.6: Sources of micronutrient fertilisers

S. No.	Fertiliser source	Nutrient content (%)
1.	Manganese sulphate	Mn– 30.5
2.	Boric acid	B – 17
3.	Ferrous sulphate	Fe – 19
4.	Ammonium molybdate	Mo – 52
5.	Chelated zinc Zn-EDTA (Ethylene diamine tetra acetic acid)	Zn – 12
6.	Chelated Fe-EDTA	Fe – 12
7.	Zinc sulphate monohydrate	Zn – 33
8.	Zinc coated urea	N – 43 + Zn – 2

Practical Exercise

Activity 1

Identify organic and inorganic sources of fertilisers.

Material required: FYM, compost, vermicompost, poultry manure, blue-green algae, *azolla*, PSB, azotobacter, neem cake, chemical fertilisers (NPK), notebook, pen, etc.

Procedure

- Collect the above mentioned organic and inorganic fertilisers sources and label them.
- Write down the characteristics of each fertiliser.

Activity 2

Visit a nearby field and note down the process of green manuring being followed there.

Material required: pen, pencil, notebook, etc.

Procedure

- Visit a nearby field.
- Identify the green manure crop being used there.
- Discuss with the farmer and note down the seed rate, and sowing method of green manure crop.
- Note down the age of the green manure crop.
- Observe and note down the process of green manuring.
- Present your observations before the class.

Check Your Progress

Notes

A. Fill in the Blanks

1. Only ________ elements are essential for plant nutrition.
2. Elements that are used in relatively large amounts are called __________ nutrients.
3. Seed rate of *dhaincha* (*Sesbania aculeata*) for green manuring is _____________.
4. Growing and incorporation of tender biomass of legume species into the soil is known as ___________ manuring.
5. Micronutrients can be applied readily through ________ application.

B. Multiple Choice Questions

1. Ca, Mg and S are called _________.
   (a) primary nutrients (b) secondary nutrients
   (c) micronutrients (d) None of the above
2. A 100-kg bag of Diammonium phosphate contains ____________.
   (a) 18 kg P (b) 46 kg P
   (c) 80 kg P (d) 120 kg P
3. Bio-fertiliser that can be used for rice crop includes ____________.
   (a) azolla (b) *phosphobacteria*
   (c) *azospirillum* (d) All of the above
4. The botanical name of sunnhemp is ____________.
   (a) *Crotalaria juncea* (b) *Tephrosiapurpurea*
   (c) *Sesbania aculeate* (d) *Sesbania speciosa*
5. Chelated Fe-EDTA contains __________ per cent of Fe.
   (a) 8 (b)12 (c) 18 (d) 22
6. Zinc coated urea contains ____________ per cent of N.
   (a) 52 (b) 33 (c) 46 (d)43

C. Match the Columns

A		B	
1.	Sunnhemp seed rate kg/ha	(a)	46% nitrogen
2.	*Dhaincha* green biomass	(b)	36 kg
3.	100-kg urea bag contains	(c)	25–35 kg
4.	Inert material in 100-kg DAP	(d)	25 t/ha

D. Subjective Questions

1. Write a brief note on essential nutrients required by plants.
2. Describe the methods of bio-fertiliser application.

Notes

3. Differentiate between the following.
   (a) Macronutrient and micronutrient
   (b) Primary and secondary nutrients
4. Define the following.
   (a) Organic manure
   (b) Bio-fertiliser
   (c) Green manuring

Session 3: Methods and Time of Fertiliser Application

Fertiliser application

The nutrient requirement of every plant is different. It also depends on the type of soil a plant is grown in and the climatic conditions of the area. Besides, the nutrient requirement of a crop differs at different stages of growth. Therefore, there must be timely and adequate application of manures and fertilisers. Response of fertilisers and manures differ as per the types of soil.

Considerations for fertiliser use

- Nutrient content in manures and fertilisers
- Nutrient requirement of a particular crop to be grown
- Timing and methods of manure and fertiliser application
- Residual effects of manures and fertilisers on succeeding crop
- Response of crop after fertiliser application
- Cost of fertilisers

Objectives of fertiliser application

Various methods are used for fertiliser application. The application of fertilisers fulfills the following objectives.

- Makes easy availability of fertilisers to crops
- Minimises fertiliser loss

Application of solid fertilisers

Broadcasting

In this method, manures or fertilisers are spread uniformly by hand all over the field. It can be done

before and during transplanting or in standing crop. Broadcasting is two types.

- Basal application at the time of sowing
- Top dressing during crop growth period

Placement

In this method, fertilisers are added to the soil near the seed, seedling or growing plant before or after the sowing of crops. It includes the following.

Plough furrow or single placement

It refers to the application of fertiliser in narrow bands beneath and by the side of crop row or furrow. This is done during the process of ploughing. In this method, fertiliser is applied in moist soil, where it can become easily available to the growing plants during dry seasons.

Deep or sub-surface placement

Placement of fertiliser is, generally, practised for the application of nitrogenous (Ammonium sulphate and urea) and phosphatic fertilisers. Such fertilisers are placed near the root zone as in case of paddy fields.

Localised placement

In this method, fertiliser is applied the soil close to the seed or plant. This method is suitable when relatively small amount of fertilisers are to be applied.

Pellet application

In this method, nitrogenous fertiliser is placed in the form of a pellet at a depth of 2.5–5 cm between rows of plants. These pellets are prepared by mixing one part of fertiliser and 10 part of soil (1:10 ratio). Application of fertilisers by this method improves nitrogen use efficiency in paddy crops.

Application of liquid fertilisers

Foliar application

Dilute solution of fertilisers is sprayed on the foliage of growing plants. Minor nutrients like zinc, boron, iron, copper and manganese are effectively applied by

NOTES

NOTES

this method. However, if required, major nutrients can also be applied as foliar sprays. Leaf scorching occurs due to uncontrolled concentration of solution during foliar spray.

Fertigation

In this method, fertilisers are applied through irrigation water. Nitrogen is the principle nutrient commonly used for this purpose. Also, highly soluble forms of zinc can be readily applied in this way.

Stages of fertiliser application

For obtaining maximum benefits, fertilisers need to be applied to the soil at three stages of the crop cycle.

Basal application

Application of fertilisers before sowing or transplanting is referred to as 'basal application'. Fertilisers may be broadcast or mixed in the soil at the time of puddling to ensure adequate supply of nutrients during the critical seedling establishment phase.

First top dressing

Fertilisers must be top dressed by broadcasting in the field when seedlings enter the active tillering stage, i.e., 20–25 days after transplanting.

Second top dressing

Immediately after panicle initiation (boot leaf stage), second top dressing of fertiliser must be done by broadcasting method. This ensures complete grain filling, increases the size and weight of the grains, and improves the physical quality and protein content of the produce.

Fertiliser dose calculation

For fertiliser dose calculation in a given area, a number of factors need to be considered. These include the following.

- Percentage of nutrient content in fertiliser material
- Desired dose of application
- Area to be covered by a fertiliser

Using the recommended rate of, say 40 kg/ha, calculate the amount of fertiliser required.

$W = A \times R \times 100 / P$

Where,

W = weight of fertiliser to be applied (this is what you want to know)

A = area to be fertilised (in hectares)

R = desired rate of application

P = percentage of nutrient element the fertiliser contains

Suppose, the measured field's area is 1.5 ha.

Use the formula

$W = A \times R \times 100/P$

Where,

W = ?

A = 1.5 ha

R = 40 kg/ha for this application (top dressing)

P = 46%

Then,

$$W = 1.5 \times 40 \times 100/46$$
$$= 6000/46$$
$$= 130.0 \text{ kg}$$

It is clear that the said area will need fertiliser application of 130 kg urea.

Each bag of urea weighs 50 kg. Therefore, to convert 130 kg into bags, divide 130 kg by the weight of one bag.

130 kg = 130 kg / 50 kg = 2.6 bags

Practical Exercise

Activity

Calculate the fertiliser quantity needed for paddy crop.

Material required: fertiliser, notebook, pen, pencil, etc.

Procedure

- Measure the plot area under paddy cultivation.
- Check the recommended dose of nitrogen for paddy plant.
- Calculate the quantity of urea to meet the recommended dose of nitrogen.
- Carry out mathematical calculation.

NOTES

NOTES

Suppose, the measured field's area is 1.5 ha. Use the formula W = (A×R)/P

Where,

W = ?

A = 1.5 ha

R = 40 kg/ha for this application (top dressing)

P = 46%

Then,

W = 1.5 ha × 40 kg/ha / 0.46

= 60 kg/0.46

= 130.0 kg

It is clear that the said area will need fertiliser application of 130 kg urea.

Each bag of urea weighs 50 kg. Therefore, to convert 130 kg into bags, divide 130 kg by the weight of one bag.

130 kg = 130 kg / 50 kg = 2.6 bags

Check Your Progress

A. Fill in the Blanks

1. When fertiliser is applied during the process of ploughing, the method is called __________.
2. Spreading or broadcasting of fertilisers in standing crop is known as ___________.
3. The depth of nitrogenous fertilisers for pellet application is ___________.
4. The process of spraying fertiliser solutions on the foliage of growing plants is called ___________.
5. Second top dressing of fertiliser must be done at the ____________ stage.

B. Multiple Choice Questions

1. Application of fertilisers into soil close to seed or plant is termed __________.
   (a) pellet application (b) broadcasting
   (c) top dressing (d) localised placement
2. Scorching of paddy leaves is caused by _____________.
   (a) controlled top dressing
   (b) uncontrolled dose of foliar spray
   (c) basal application
   (d) drill placement
3. ____________ of fertilisers is, generally, practised in nitrogenous and phosphatic fertiliser.
   (a) Sub-surface placement
   (b) Plough furrow placement
   (c) Localised placement
   (d) Pellet application

4. Application of fertilisers through irrigation water is known as _____________.
   (a) fertigation
   (b) top dressing
   (c) deep placement
   (d) broadcasting

C. Match the Columns

A		B	
1.	Basal application	(a)	Nitrogenous fertiliser
2.	First top dressing	(b)	Active tillering stage
3.	Pellets	(c)	Band placement
4.	Single placement	(d)	Before sowing

D. Subjective Questions

1. Describe the methods of fertiliser application.
2. Explain the methods of applying fertilisers in solid form.
3. Explain the methods of applying fertilisers in liquid form.
4. Define the following.
   (a) Top dressing
   (b) Fertigation

Session 4: Nutrient Deficiency Symptoms in Paddy

Nitrogen

Nitrogen increases the vigour and growth of paddy plants. It imparts green colour to the plants by synthesising chlorophyll necessary for photosynthesis, promotes leaf, stem and root growth or elongation (height, size, tillers, leaf size, etc.). It is also helpful in promoting the development of panicle.

Deficiency symptoms

Deficiency symptoms start at leaf tips, which become chlorotic and progress along the midrib until the entire leaf is dead. The plants may develop weak stems and exhibit slow growth.

Notes

NOTES

Corrective measures

- Before sowing or transplanting of paddy and during crop growth, apply sufficient nitrogen fertiliser as recommended in the soil test report.
- Carry out foliar application of 1 per cent urea solution when the symptoms are observed every week till the symptoms disappear.

Phosphorus

Phosphorus stimulates root development in young plants, thereby, increasing the number of root hair and their ability to absorb nutrients from the soil. It also helps the seedlings to recover rapidly from transplanting shock. It imparts resistance from drought, facilitates nitrogen absorption, and promotes early flowering and ripening. It also increases protein content of the grains (food value) and invigorates the germinating power of seeds.

Deficiency symptoms

There is purple colour development in lower part of the culms of plants. This deficiency makes the leaves bluish-green and causes stunting of the plants, underdeveloped root system and less number of tillers.

Corrective measures

- If a soil is deficient in phosphorus, then applying phosphorous bacteria as seed coating or using seedling dip method is effective.
- Add phosphatic fertiliser to the soil.
- When soil pH is low, broadcast rock phosphate before flooding in field

Potassium

Potassium strengthens the cell walls, makes the plant, sturdy, helps it to withstand adverse weather conditions and increases the plants' resistance to pathogens. It increases the size, weight and protein content of the grains, thus, improving their appearance.

Deficiency symptoms

The symptoms are scorched appearance along the leaf margins, dark colour of the leaves (spreading from the tips), chlorotic areas on leaf and panicles, weak stems (tendency to lodge), droopiness, reduced photosynthesis and consequent slower growth.

Corrective measures

Potassium deficiency can be corrected by foliar spray of aqueous solution of potassium chloride (KCl) 5 g/lat at an interval 15 days till the symptoms disappear.

Sulphur

Sulphur helps in chlorophyll formation and encourages vegetative growth in plants. It is essential for the formation of proteins, enzymes and certain volatile compounds, including rice bran oil. Moreover, it increases root growth, and stimulates seed formation, quality and size of the grains.

Deficiency symptoms

Deficient plants appear pale green with light green coloured young leaves. Other important symptoms are yellowing of the plants, chlorosis in young leaves, reduced height and reduced tillers with shortened panicles.

Corrective measures

- Apply slow releasing sulphur forms (gypsum, elemental S) into the soil, where leaching is a problem.
- Apply 10 kg wettable S/ha in case of moderate deficiency. For severe deficiency, application of 20–40 kg S/ha is recommended.

Zinc

Zinc helps in the formation of chlorophyll in plants and also influences the formation of important growth hormones. It is associated with water uptake in plants.

NOTES

NOTES

Deficiency symptoms

Typical zinc deficiency symptoms appear in reddish colour on the leaves known as *khaira* disease in paddy plants. It leads to yellowing of the leaves between the veins, and the middle parts of the leaves often collapse to give a scorched appearance. In case of severe deficiency, there is reduction in leaf size. They may even turn white, and subsequently, die. Besides, the plants get stunted and produce few tillers.

Corrective measures

- Zinc sulphate ($ZnSO_4$) must be applied to the nursery seedbed, if deficiency symptoms are observed.
- Pre-soaked seeds or seedlings may be dipped in 2–4% $ZnSO_4$ suspension before sowing and transplanting.
- Zinc sulphate at 5–10 kg /ha must be applied.
- Foliar application of 0.5–1.5 per cent $ZnSO_4$ / ha at tillering (25–30 days after transplanting), 2–3 repeated applications at an interval of 10–14 days is recommended in zinc deficient soils.
- Zn chelates (such as Zn-EDTA) can be used for foliar application.

Practical Exercise

Activity

Identify of nutrients deficiency symptoms in rice plant.

Material required: pen, pencil, notebook, gloves, gumboot, nutrient deficiency symptom colour chart, etc.

Procedure

- Visit a nearby paddy field.
- Identify the deficiency symptoms in the crop.
- Match the symptoms with the colour chart.
- Note down the deficiency symptoms in your notebook.
- Write down the corrective measures to check such deficiencies.
- Present your observations before the class.

Check Your Progress

A. Fill in the Blanks

1. __________ enables the seedling to recover rapidly from transplanting shock.
2. ______________ increases a plant's resistance to pathogens.
3. Reduced number of tillers and shortened panicles indicates the deficiency of __________.
4. *Khaira* disease of paddy is caused by the deficiency of ___________.

B. Multiple Choice Questions

1. _____________ gives green colour, and enhances vigour and growth of paddy plant.
   (a) Nitrogen (b) Phosphorus
   (c) Potash (d) None of the above
2. ___________ helps in chlorophyll formation and encourages vegetative plant growth.
   (a) Potash (b) Sulphur
   (c) Zinc (d) None of the above
3. Scorched appearance along leaf margins indicates the deficiency of __________.
   (a) Potassium (b) Nitrogen
   (c) Copper (d) Zinc
4. ____________ increases root growth, stimulates seed formation quality and size of grains.
   (a) Copper (b) Zinc
   (c) Sulphur (d) Manganese

C. Match the Columns

A	B
1. Zinc	(a) Root development
2. Phosphorus	(b) Weak stems
3. Potassium deficiency	(c) Chlorophyll
4. Sulphur forms	(d) Water uptake

D. Subjective Questions

1. Discuss the following.
   (a) Nitrogen deficiency symptoms
   (b) Zinc deficiency symptoms
   (c) Corrective measures for deficiency of phosphorus

NOTES